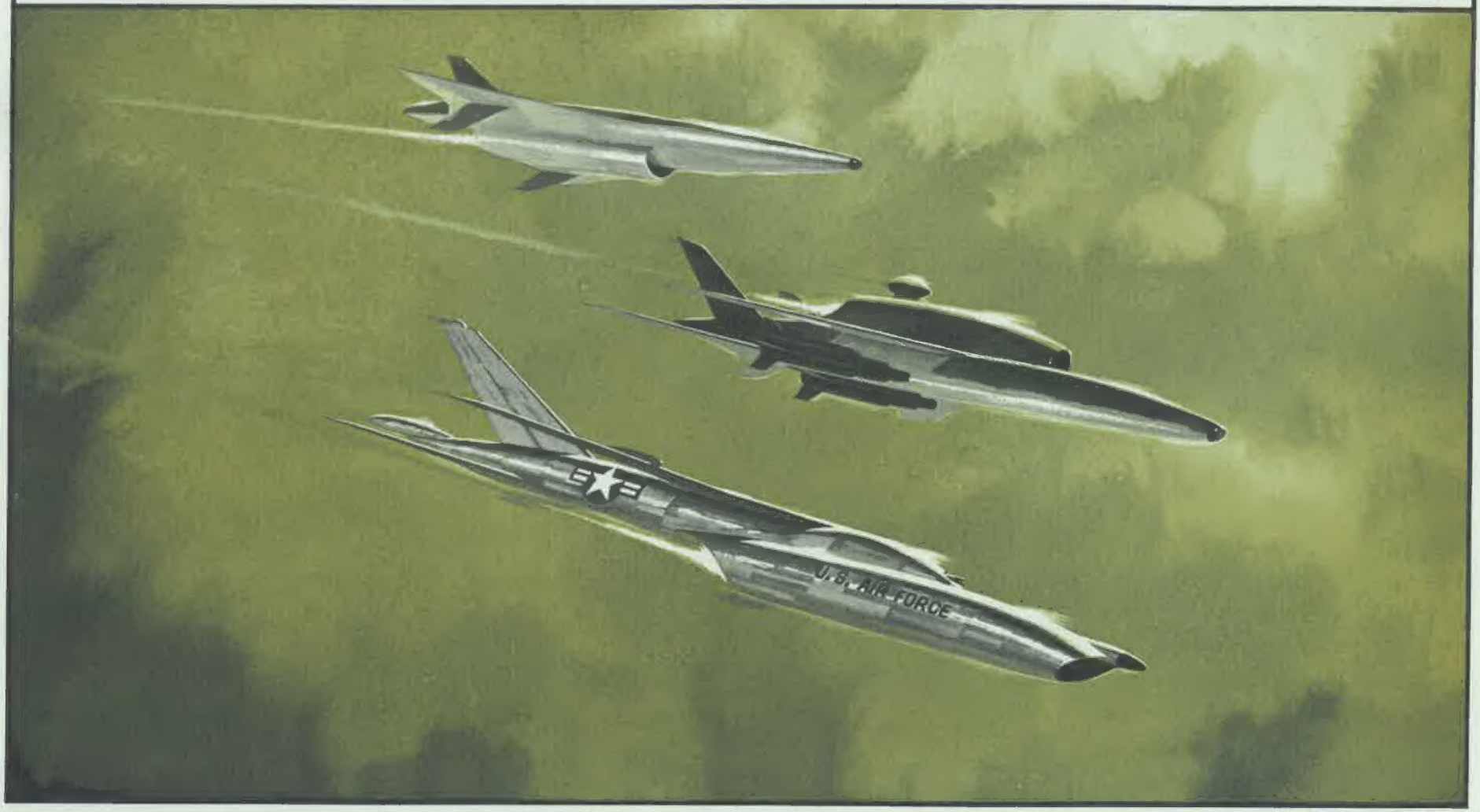
1971

MULTI-MISSION RPV STUDY
EXECUTIVE SUMMARY



TELEDYNE RYAN AERONAUTICAL RPV RCA

BACKGROUND

C. F. Kettering Unmanned Aircraft 1915

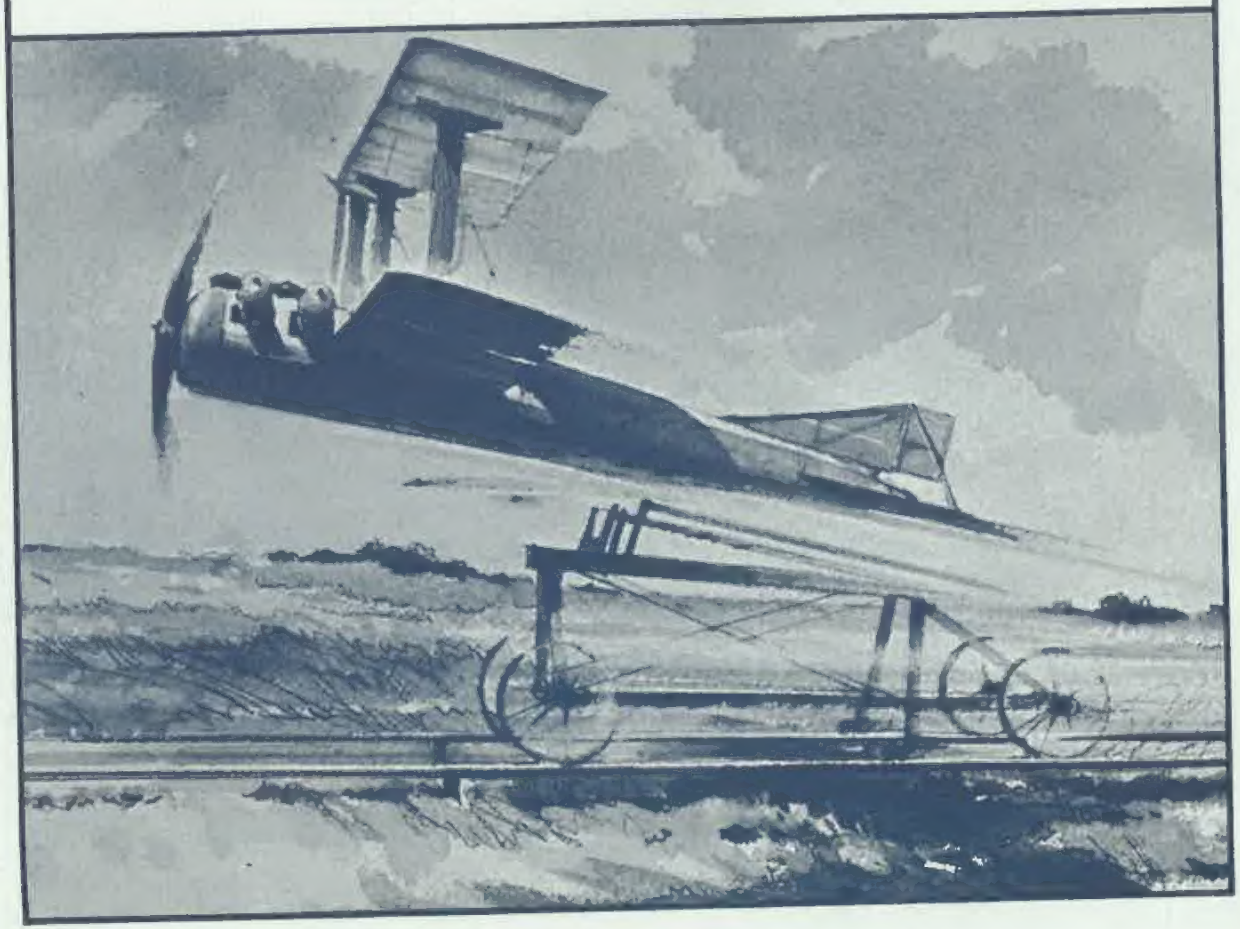
Radio Controlled Curtis Robin 1928

Hap Arnold's "Special Weapons" 1938

GB-1's Used at Cologne 1943

B-17 and B-24 "Droned" 1944

Pilotless Aircraft Branch of the Air Force Created 1946



1947 Ryan Subsonic Jet Drone (XQ-2A)
1949 RAPS-4 Ryan Automatic Pilot System
1951 XQ-2 (Ryan) Air Launched
1958 1300th Ryan Firebee I Drone Delivered
1962 Reconnaissance Drone Programs Started
1967 4200th Drone Delivered
1968 Ryan In-House Unmanned Weapon Delivery Study Program
1969 Supersonic Firebee II Prototypes Operational
1970 Model 154 "Firefly" Delivered
1971 Delivered 1st Production Supersonic Firebee II
1971 Weapon Delivery RPV Demonstration Program
1971 Multi-Mission RPV Study Program

STUDY OBJECTIVES

Teledyne Ryan Aeronautical (TRA), with RCA as principal subcontractor, has submitted a proposal for this study of Multi-Mission Remotely-Piloted Vehicle Systems, fully responsive to U.S. Air Force solicitation F33-(615)-71-Q-2429 of 21 May 1971.

The objectives of the study may be summarized as follows:

- Define PRACTICAL 1975-1980 RPV system concepts.
- Provide a QUANTITATIVE BASIS FOR USAF planning decisions.
- Provide a DEVELOPMENTAL ROADMAP for introducing the new RPV's into the USAF inventory . . . delineating alternative routes . . . identifying critical technologies . . . assessing performance, timing, cost, risk for each route.

The TRA/RCA proposal submitted to ASD on 21 July 1971, is in response to this solicitation.

A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

U.S. DEPARTMENT OF COMMERCE

TUESDAY, FEBRUARY 16, 1971

COMMERCE BUSINESS DAILY

A daily list of U.S. Government procurement invitations, subcontracting leads, contract awards, sales of surplus property and foreign business opportunities.

DEVELOPMENT STUDIES CONCERNING APPLICATION OF REMOTELY PILOTED

VEHICLES CONCEPT — Advanced Development Area KMB-71-35. The Air Force is contemplating multiple contracts, to be awarded on a competitive basis for conceptual studies concerning the applications of the remotely piloted vehicles concept to the mission roles of air-to-air combat, air-to-ground weapons delivery and reconnaissance. The conduct of the study will require parametric analyses and trades in areas unique to the RPV concept, such as command and control, as well as the conventional areas of aircraft design. The study will be in two phases. The first phase will be to optimize a vehicle design for each of the three mission areas. The second phase will require the optimization of a single vehicle design to perform all three missions in light of the results of the first phase. The Contractor selected must possess a facility clearance through the SECRET level and must have experience in the areas of vehicle conception, design, system analysis, operations, analysis, engineering, test, cost and production.

STUDY OBJECTIVES

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EXECUTIVE SUMMARY

Summary features of the TRA/RCA approach to meet these objectives are:

- Understanding in depth of the potential of RPV's and the problems in their development/deployment.
- Continual stress on lowest cost and lowest complexity, with balanced reliability and life expectancy to provide maximum system cost-effectiveness.
- Emphasis on identifying the strong variables and sensitive parameters.
- Combined team experience providing the optimum combination of demonstrated abilities in ...systems integration plus sound study methodology and practical hardware experience.
- Application of additional team resources to insure study objectives are met.
- Inclusion of outputs from in-place system study groups already working on RPV.
- Emphasis on the unique potential of RPV's, assessing the concomitant effects on design and development of manned and unmanned aircraft.
- Team ability and enthusiasm to assist AFSC in explaining RPV benefits and development alternatives to all cognizant USAF and DOD offices.

TRA/RCA UNDERSTAND THE PROBLEM—THE PAST IS PROLOGUE AND THE POTENTIAL FUTURE OF THE RPV HANGS ON THE QUALITY OF THIS STUDY.

THE PAST—TRA has a broad background in unmanned vehicles and RPV system design. A recognized leader in RPV targets, reconnaissance, and weapons delivery systems, Teledyne Ryan in 1968 started examining and planning in the broader spectrum of all future requirements and potential utilizations of unmanned aircraft. At that time, a new supersonic target development (BQM-34E) was in progress; a major AFM-375-5 program (classified) for an advanced state-of-the-art high-altitude RECCE system was under contract, and a number of in-house study efforts on future low-altitude RECCE systems were going on.

Coupling all this work with knowledge of North Vietnam air activity, we assumed heavily-defended, high-priority targets and delineated a concept of weapons delivery aircraft controlled by a remotely-located pilot in real-time. Studies and simulations in 1968 established the viability of such systems. Now, three months from flight, the TRA-developed (class.) weapon delivery RPV, the first of the new RPVs, is being readied for demonstration. TRA also participated in the USAF/RAND Remote Controlled Technology Symposium and the ASJP study team for tactical RPV applications.

We developed in-depth recognition of the myriad of problems associated with all these missions ... in command and control ... in sensors ... in data links ... in tactics and vehicle design variables. And we saw that, if RPVs were going to achieve their potential a total plan was needed that realistically considered the interrelationships among technology, required performance, cost and time. So, we formed a team to aid the Air Force to do just that.

The team is uniquely qualified to perform advanced RPV studies

Teledyne Ryan's broad background and deep current involvement in RPV systems makes TRA the appropriate team leader. The Multi-Mission Study Project Manager is Mr. William Anderson, who has the experience, enthusiasm and vision needed to guide the study. TRA will be responsible for the overall systems design and integration, the overall mission analysis, and for the air vehicle and related supporting systems.

RCA for avionics, command and control

TRA and RCA have entered into a long-term agreement designed to combine the strengths of both companies for the development of future operational RPV systems. RCA is unique in the breadth of military and commercial electronics technology and product expertise . . . and commercial "know-how" is important in keeping hardware costs low. RCA will also assist TRA in systems design and integration.

Ultrasystems and Flight Systems, Inc., for system and modeling support

Leading research/consulting firms, both are skilled in program analysis, systems engineering and advanced system design requirements analysis. Flight Systems, Inc., is particularly versed in air combat requirements and system evaluations.

The team is and has been working together

The Multi-Mission Study Project Team occupies committed engineering space at TRA's San Diego facility. In addition, supporting task teams are at work on specified tasks at RCA's facilities in California, New Jersey and Massachusetts.

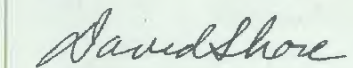
TRA/RCA propose a total systems analysis and systems synthesis approach, looking for the critical technologies, design parameters and tradeoffs.

- We will work toward the objectives from a parametric approach, using the technologies forecast to be available as a function of time, and starting from preliminary point designs containing many new concepts.
- We will iterate our designs and refine them, always looking for those critical factors which can make or break the RPV . . . those sensitive parameters where a 5 percent change can cut a cost by 50 percent or improve performance by 25 percent . . . and labeling those that won't significantly affect the performance or cost.
- We will concentrate on such key technologies as those related to:
  - . . . putting man in the loop where he can be effective
  - . . . efficient aerodynamic configurations
  - . . . multi-RPV position location and control
  - . . . low cost propulsion
  - . . . recovery for rapid turnaround
  - . . . jam resistant, wideband data links
  - . . . multi-spectral sensors
  - . . . low-cost materials
  - . . . damage absorbent structures
  - . . . secure two-way control links

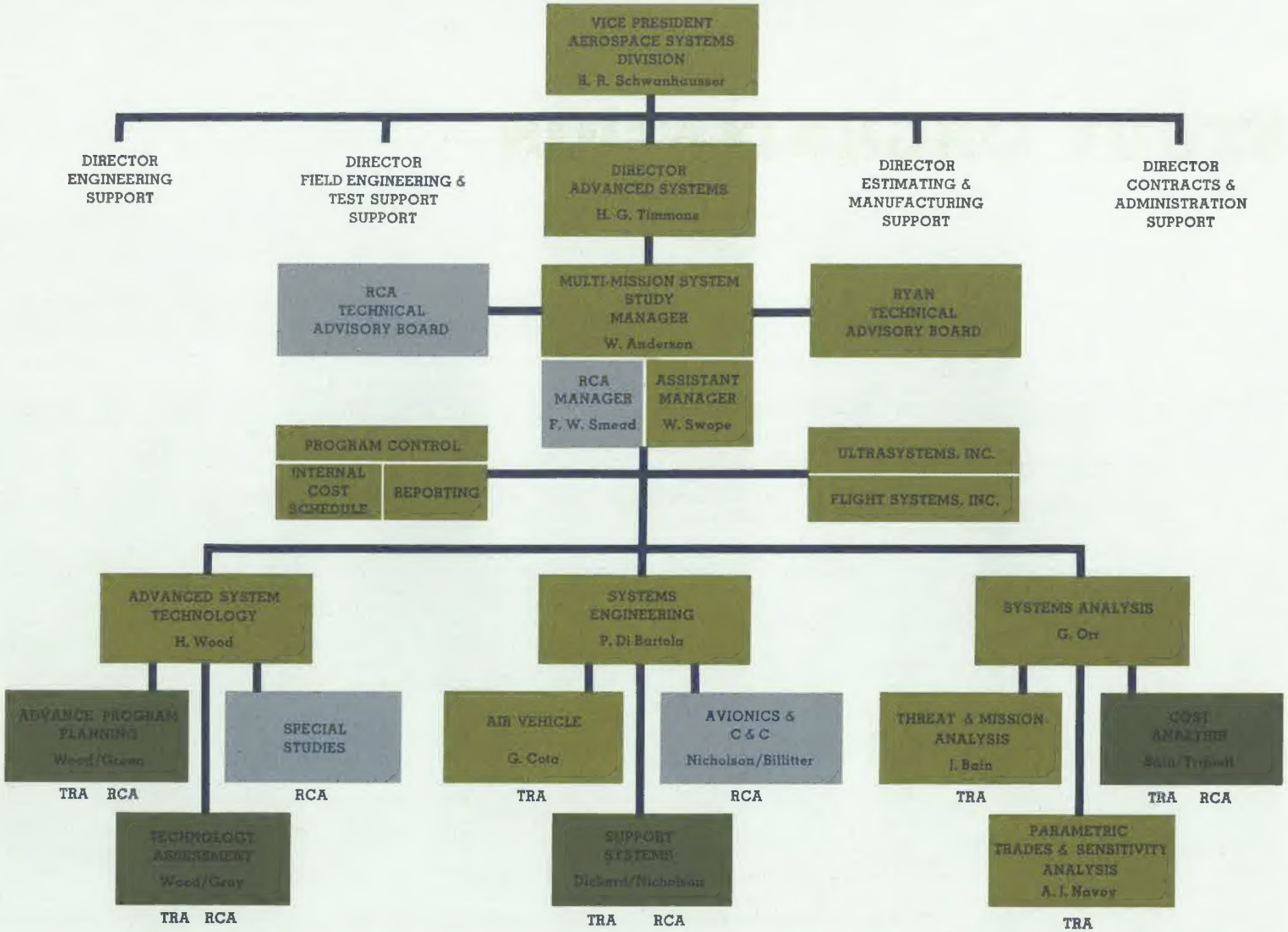
Commitment

The TRA/RCA team will receive the management support and resources needed for successful fulfillment of all of the needed work, as envisioned by the Air Force in structuring the RFP.

R. R. Schwanhausser
Vice President
Aerospace Systems
TRA



D. Shore
Division Vice President
Government Plans and Systems
Development
RCA


VICE PRESIDENT
AEROSPACE SYSTEMS
DIVISION
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ENGINEERING
SUPPORT
DIRECTOR
FIELD ENGINEERING &
TEST SUPPORT
SUPPORT
DIRECTOR
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MANAGER
W. Anderson
RYAN
TECHNICAL
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RCA
MANAGER
F. W. Smead
ASSISTANT
MANAGER
W. Swope
PROGRAM CONTROL
INTERNAL
COST
SCHEDULE
REPORTING
ULTRASYSTEMS, INC.
FLIGHT SYSTEMS, INC.
ADVANCED SYSTEM
TECHNOLOGY
H. Wood
SYSTEMS
ENGINEERING
P. Di Bartola
SYSTEMS ANALYSIS
G. Orr
ADVANCE PROGRAM
PLANNING
Wood/Green
TRA RCA
SPECIAL
STUDIES
RCA
AIR VEHICLE
G. Cota
TRA
AVIONICS &
C&C
Nicholson/Billitter
RCA
THREAT & MISSION
ANALYSIS
J. Bain
TRA
COST
ANALYSIS
Bain/Trippett
TRA RCA
TECHNOLOGY
ASSESSMENT
Wood/Gray
TRA RCA
SUPPORT
SYSTEMS
Dickard/Nicholson
TRA RCA
PARAMETRIC
TRADES & SENSITIVITY
ANALYSIS
A. J. Navoy
TRA

STUDY ORGANIZATION

Allocations of study responsibilities

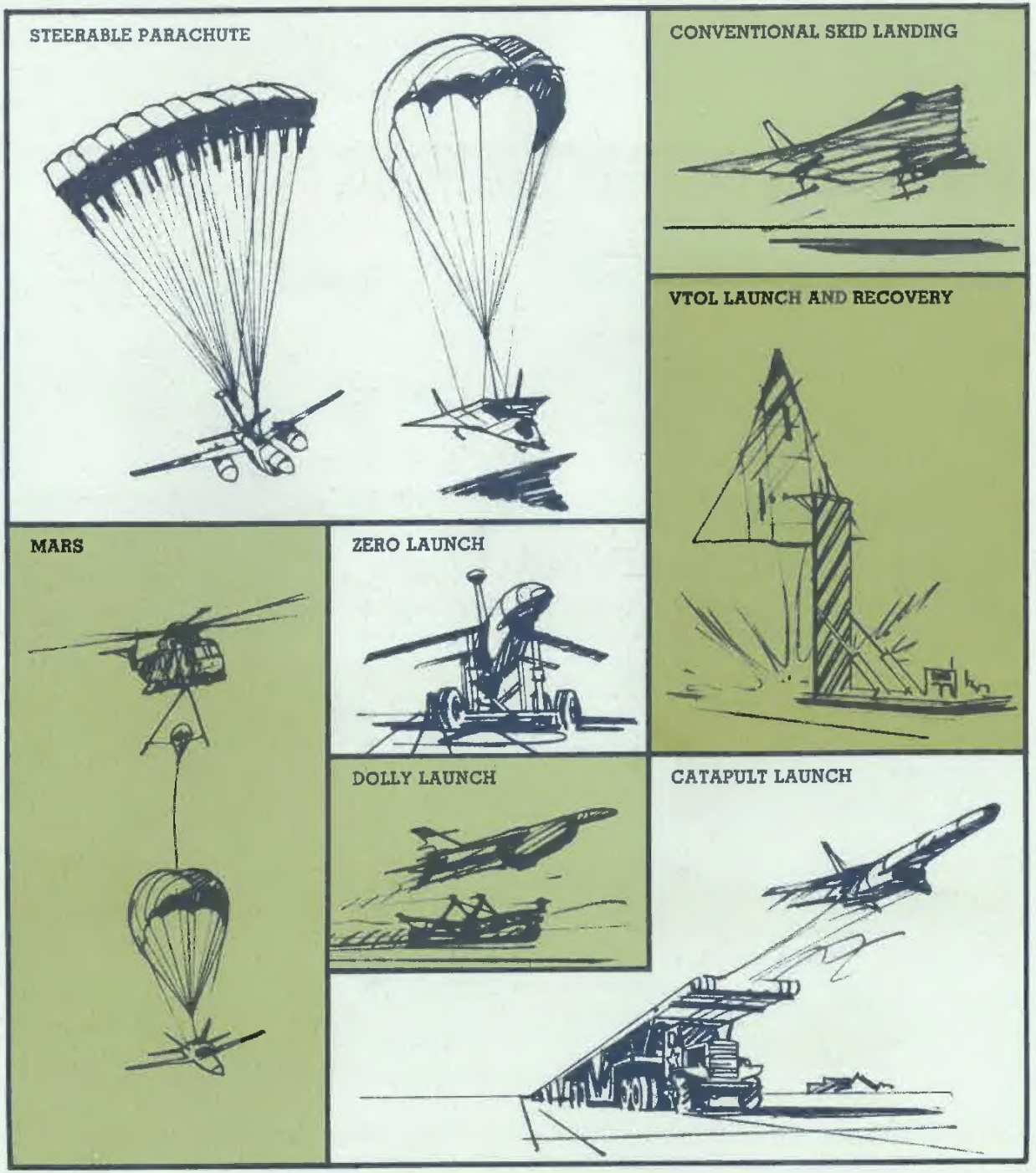
JOINT TRA/RCA RESPONSIBILITY	TRA RESPONSIBILITY	RCA RESPONSIBILITY
● Mission Analysis	● System Integration	● All Sensors—Except Photographic
● Threat Analysis	● Vehicle and Vehicle Configuration	● Weapons Delivery Designation and Control
● Definition of Mission Goals—Criteria	● Autopilots	● C&C and Tracking Systems Including Relays
● Measures of Effectiveness	● Propulsion Systems	● Navigation Systems
● Sensitivity Analyses	● Fuel Systems	● Airborne/Ground Recording Systems
● Performance Apportionment	● Launch/Recovery Systems	● Feasibility of Satellites for Relay, Nav.
● Human Factors Man-machine Interface	● System Transportability and Mobility	● Digital Data Processing
● Integration of RPV Systems With Force Structure	● RCS/IR Masking	● Secure/Anti-jam Communications
● Program Planning	● Photographic Sensors	● Ground/Airborne Control Centers
	● Ordnance Systems	● Automated Pattern Recognition
	● Destruct Systems	● Position Location, IFF, Collision Avoidance
	● AGE	● Automated Testing/Checkout
		● Special Displays/Simulations
		● Computer-aided Life-cycle Costing

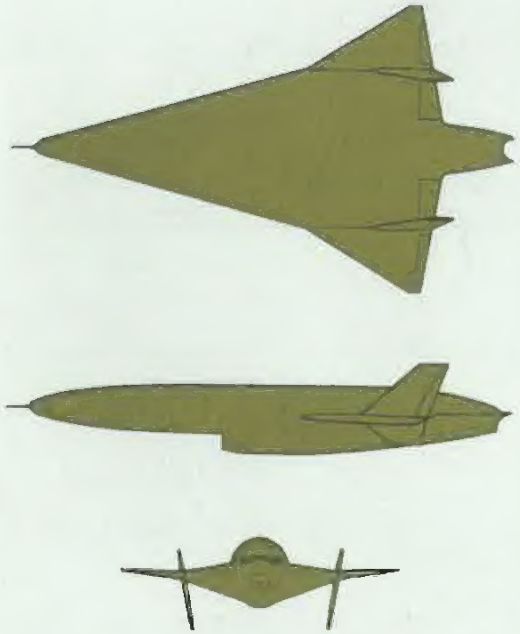
The TRA/RCA study organization has been structured to provide a closely integrated effort, with well defined areas of responsibility.

SUPPORTING STUDIES

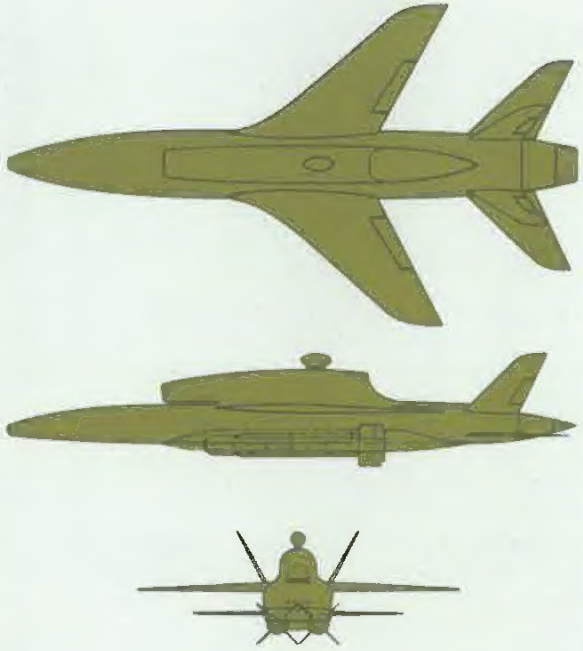
Supporting research and studies will supplement the contractually funded work proposed.

These supporting studies are part of the non-contractually funded programs of both TRA and RCA, plus additional inputs from related Government funded contracts for research studies and feasibility demonstrations. Some of the supporting research and study efforts are shown on the following pages.

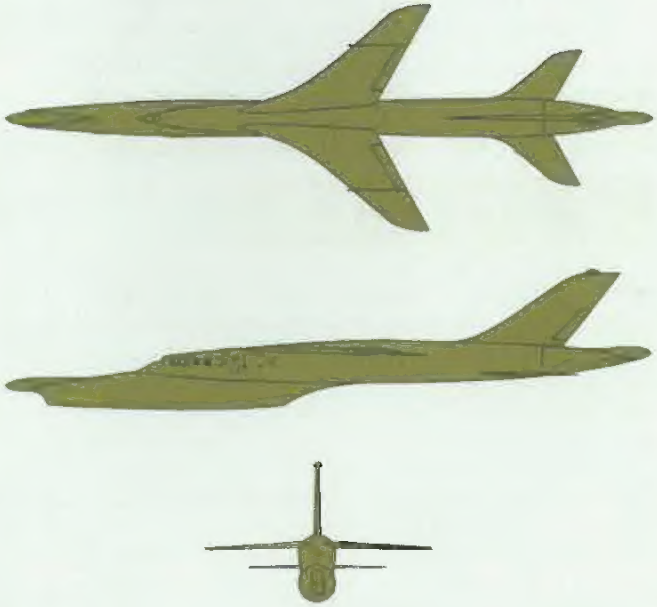




LOW ALTITUDE PENETRATOR RPV
CONFIGURATION 4



WEAPONS DELIVERY RPV
CONFIGURATION 7



AIR SUPERIORITY FIGHTER RPV
CONFIGURATION TM-AS-3

Flight simulation studies

- Full six degree of freedom simulation labs using EAI 8900 Hybrid Computing System.
- Terrain generation equipment for TV display.
- Computer simulation programs available for rapid simulation of man-machine interface studies on AFCS and ground (or air) remote control station.
- Weapon Delivery RPV Demonstration System man-machine interface studies being conducted.
- Navigation and low altitude control systems for RPV's have been and are being studied.

Launch and recovery systems

- Continuous studies of improved and more cost-effective launch and recovery systems are a basic element in TRA product improvement programs.
- Every possible system has been studied at one time or another, with the most promising ones receiving special attention.
- In-flight recovery by fixed-wing manned aircraft have been investigated as attractive means of extending the range of RPV's.

Vehicle configuration design

- Continued detailed design studies of RECCE/EW systems since 1955.
- Over 800 RECCE/EW RPV systems produced.
- Hundreds of designs and studies available for reference.
- Air combat design trade-off studies made using Flight Systems Inc. Air Combat Evaluation (ACE) technique and computer program.
- Nine years of Weapon Delivery system concept and design studies, culminating in TRA Model 234 Weapon Delivery demonstration program.

Mission and threat analyses and operational concepts

- In depth studies conducted for HAVE LEMON RPV program.
- Command and control systems conceived to handle thirty RPV sorties per hour using available systems.
- Continued studies and engineering design efforts to evolve and develop advanced BGM 34A system capable of two year IOC for defense suppression missions.

Flight feasibility demonstration

- USAF contracted development of RPV weapon delivery system in progress.
- Successful wing-mounted pylon firing of inert Maverick missile conducted in flight.
- Full remotely piloted weapon delivery demonstration flights using TV and proportional control scheduled for September, 1971.
- TRA Model 147-G loaned to USAF Flight Dynamics Lab for joint modification program to investigate fully free maneuvering RPV for air combat and research.
- Automatic Bi-modal LORAN navigation system designed for early demonstration of high accuracy (±300 Feet) mid-course automatic navigation on TRA Model 147-SD.

Aircraft position location

- Cooperative and non-cooperative radar systems being studied by RCA. Space satellite systems have been designed by RCA.
- RCA led NSIA study on aircraft position location, ATC, IFF and collision avoidance.

Automatic pattern recognition

- RCA has developed analog threshold logic techniques for automatic pattern recognition.
- Automatic speech recognition equipment has been delivered to the U.S. Government.
- Some laboratory success in optical and IR pattern recognition and target recognition and identification.

Penetration and vulnerability

- Computer models (PENSAM) are constantly used to support TRA operations analysis studies.
- Relative survival probabilities for all types of mission scenarios.
- Includes effects of decoys and ECM.

Secant

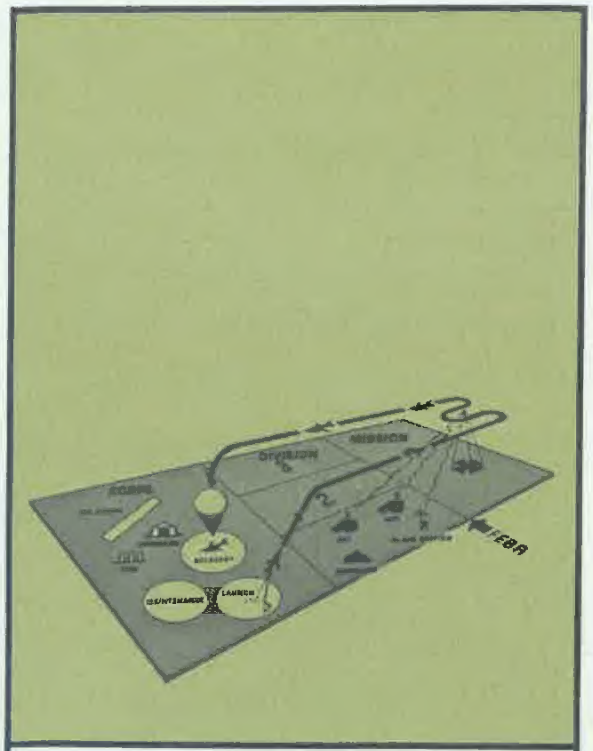
- RCA currently developing low cost aircraft collision avoidance system—SECANT.
- Pseudo-random code generation and cooperative transponders.
- Constant surveillance and alarm features with option for automatic avoidance control commands.

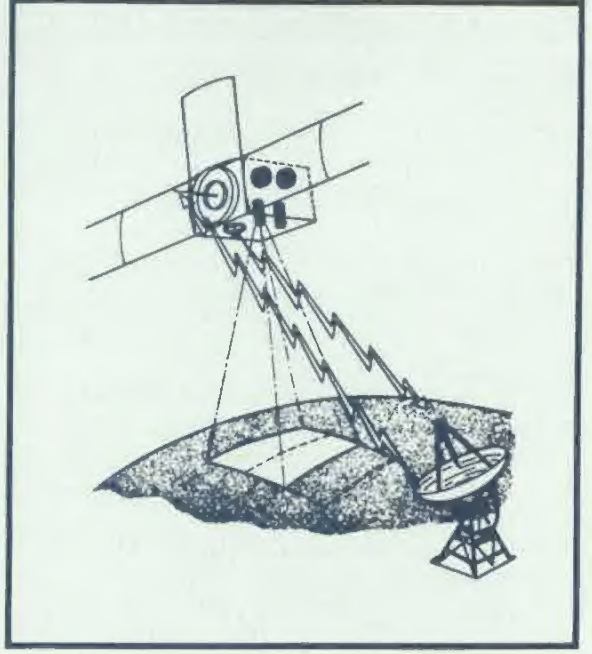
Space satellite technology forecasts

- DOD sponsored studies to develop time-phased, quantified data on space satellite services in the 1975-1980 time frame.
- Includes navigation, aircraft position monitoring, relay systems and tactical control applications.

Apollo VHF ranging

- High Resolution Ranging
- Narrow Band Radio "Add-On"
- Simultaneous Voice and Ranging





Independent research and development

- M108—Rain and Chaff Clutter Suppression
- M109—Multipath Error Reduction
- M118—Phased Array Target Handling Effectiveness and Scheduling
- M130—Signal Processor High Speed-High Capacity Packaging Concepts
- M131—Thick Film Hybrid Technology for Advanced Radars
- M135—Clutter, Noise, ECM Suppression by Pseudo Random Coded Waveforms
- M136—Signal Processing by Surface Wave Acoustic Technology
- M142—High Performance Aircraft "Form Factored" Phased Array Antenna

Advanced tactical warfare concepts

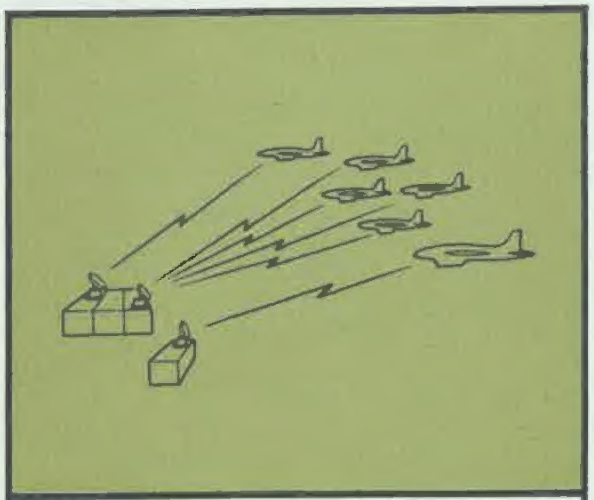
- RCA studies for U.S. Marine Corps (MARCES) provides data base for electronic targeting devices, sensors and communication equipment.
- Studies will assist in definition of operational concepts of RPV's during Task 2 and 3.

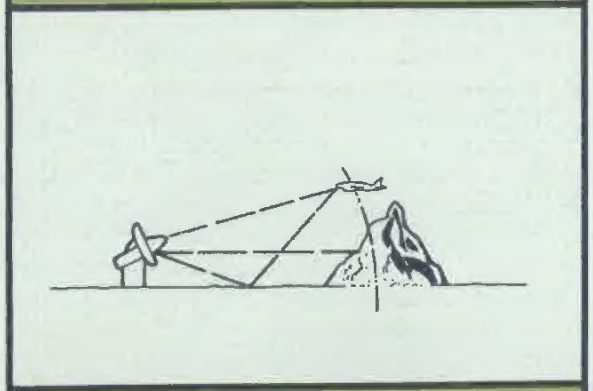
Human factors studies

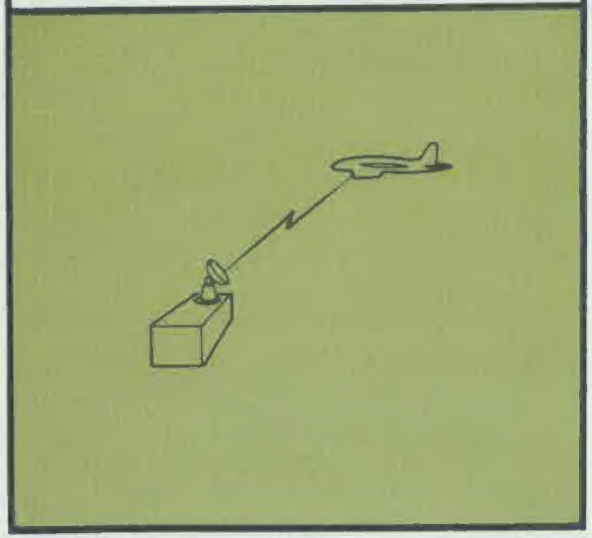
- RCA-developed tools determine operator workloads, system throughputs and potential bottlenecks using man-machine systems simulation.
- Resources Allocation Scheduling Program (RASP) assesses number and skill types for manning estimation—adaptable for multiple track and control manning studies.
- Can be used for assessing man-machine concepts and human factors design.

Classified pilotless A/C study

- Command Link Preliminary Design
- Evaluation of Propagation Effects
- Frequency Band Selection
- Ground Terminal/Antenna Sizing
- Tracking Subsystem Configured
- A-J growth "Add-On" to Command Receiver







Drone control study

- Trade-Offs of Required Data Rate
- HF/C Band Control System Trade-Offs
- On-Board Equipment Analyzed in Trade-Offs
- Analyzed Ground-Control Autopilot Interface
- Evaluated Operator/Computer Control Functions
- Considered Multidrone Tracking, Control and TLM
- Field Problems Identified by Site Visits
- Problems of Low Angle and Over-the-Horizon Track Studied
- Evaluated Operator Display Systems

RCA integrated drone system study

- Monopulse Tracking
- Unified Command, Track, and Telemetry For Target Drone Control Through 1985
- Single Frequency, Time Division Multiplex System Models Established for Trade-Off Angle and Range Tracking on Telemetry Signal
- Clutter Interference and Over-the-Horizon Control
- Time-Shared Antenna for Multiple-Drone Operation
- Computer Subsystem-Automatic Checkout and Drone Control
- Drone Range 0.2 to 250 N. Mi; Altitude 50 to 100,000 Ft.
- Manual, Semi-Auto and Automatic Drone Control Modes

Low angle tracking—anti-multipath techniques

- Offset Null Tracking—M109 IR&D Investigation—Software Approach
- Complex Indicated Angle—NRL Contract—Hardware Approach
- Multi-Beam Method—Six Beam Adaptive—NRL Contract—Hardware Approach
- Techniques Applied to MFAR (AEGIS), AN/TPS-59 (3D Radar) and AN/TPQ-27

AN/TPS-59 three dimensional tactical surveillance radar

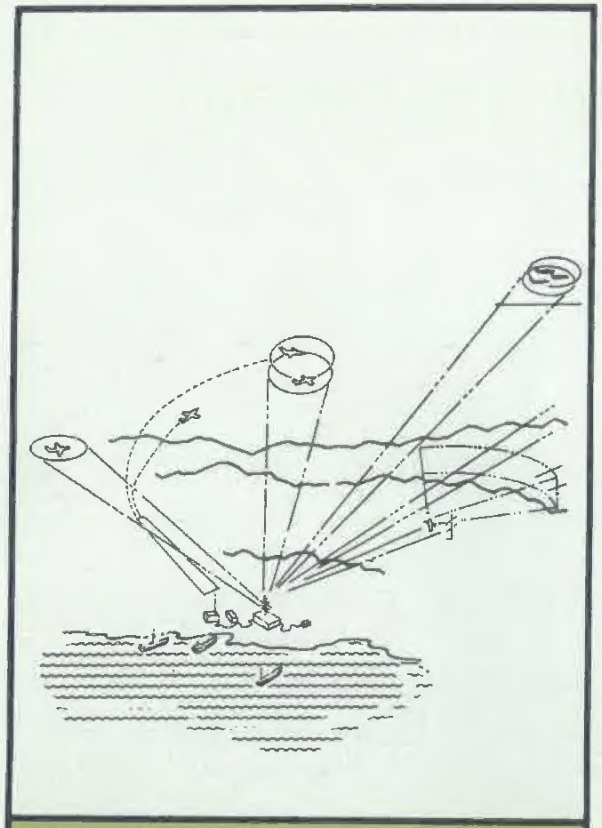
- Wide Bandwidth Pulse Coding
- Solid State Advanced Radar Technology
- Automatic Track Filtering of Moving Clutter
- High Resolution Track-While-Scan Measurements
- Digital Processing Directly in Frequency Domain
- Assault Radar with Autonomous GCI Backup Capability
- Antenna Pattern Control for Minimum Ground Interference
- Single Dwell Multiple Target Detection and 3-D Measurement
- Three Dimensional Track in Adverse Weather and Severe Jamming
- Frequency Diversity for Penetration of Clutter, Rain, Chaff and Jamming
- Man/Machine Analysis of System Functions

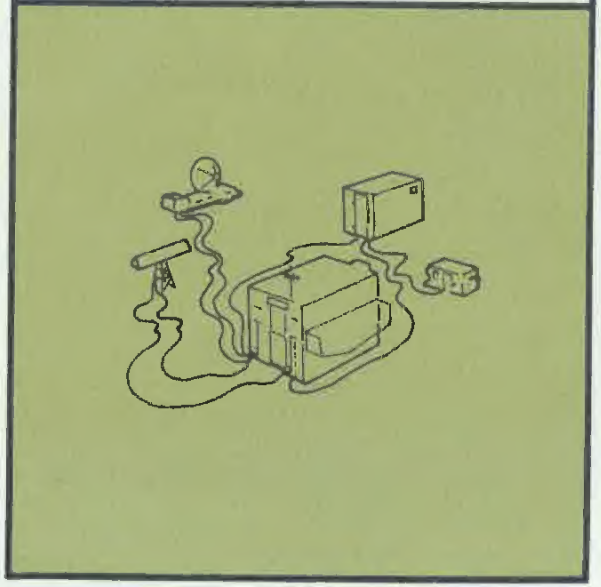
Ultra-high speed PN code generator and bi-phase modulator

- 43-Stage Shift Register Generator
- Operating at Speeds Up to 200 Megabits/Second
- Pseudo-Noise Code Generator and Bi-Phase Modulator
- Approximately 2×10^{11} Different Maximal Length Codes
- Maximum Code Bit Length Approximately 8.8×10^{12} Bits
- Computer Program Written for Feedback Connection

Lunar communications relay unit (LCRU)

- Requires Less Than 100 Watts
- Briefcase-Sized Communications System
- Measures 5"x13"x12" and Weighs 50 Pounds
- Could Permit Full-Color Television from Moon
- Will Receive Transmissions from Earth Without Relay
- Will Transmit Voice, Telemetry and Color TV Without Relay





AN/TPQ-27 radar course directing central

- 19 Computer Program Modules
- IFF Track-While-Scan System
- Synthetic Video Digital Display System
- Direct Control of Aircraft Autopilot
- Uses AN/UYK-7 for Control and Processing
- Use of Various Computers Studied
- All Weather Precision Flight Path Guidance and Bombing
- Ground Controlled Radars—Simultaneous Multiple Aircraft
- Coordination of Man/Computer Control Functions
- Integrated Radar Operator/Controller Console
- Analysis of Controller and System Load Handling

Condor A-J TV study

- Wide Band Video
- High A-J Processing
- Missile Environment

Fast frequency hopping synthesizer development

- 1 Microsecond Settling
- 4096 Frequencies
- 13 MHz Bandwidth

ICNI (Integrated Communication/Navigation/ Identification) studies

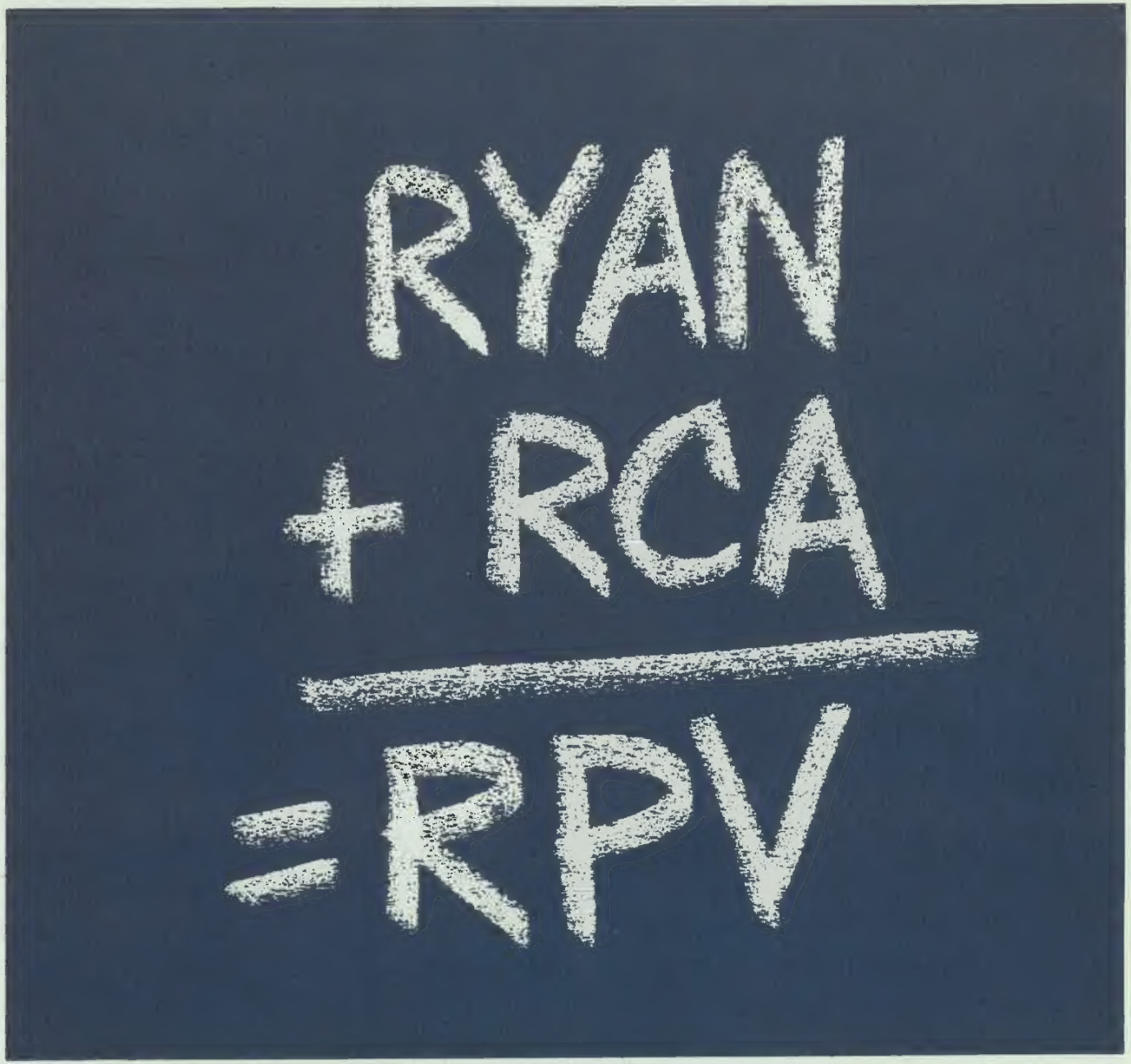
- 100 MHz Bandwidth
- Frequency-Time Hopping A-J
- Simultaneous Ranging and Communication

A-J data link development

- 25 Megabit Pseudo-Noise Keying
- 24 Hour Pseudo-Noise Codes
- In Excess of 30 db A-J
- Field-Verified Performance
- Maximum Use of IC Technology

RCA AMR study

- Mission Analysis to Establish Data Rates
- Aircraft Instrumentation Pod Synthesis
- Multi-Lateration Metric Measurement System Analyses
- Communications and Computational Requirements Definition
- Display Concept for Post Mission Pilot Debriefing
- Transponder Interrogation/Reply Formats Developed
- Discrete Address Time-Ordered Interrogations



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